Osteomeatal Complex: A Study of Its Anatomical Variation Among Patients Attending North Bengal Medical College and Hospital

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Abstract Lateral nasal wall of each nasal cavity provides the final common pathway of drainage of the mucociliary clearance of frontal, maxillary and anterior ethmoidal air cells. Anatomical variants like concha bullosa, Haller cells, agger nasi cells, enlarged bulla ethmoidalis may obstruct the mucociliary clearance through osteomeatal complex and cause rhino sinusitis. The objectives were to find out the anatomical variation of osteomeatal complex and its dimensions when present. The present study was a descriptive, hospital based cross sectional study carried out in the outpatient departments of North Bengal Medical College and Hospital, West Bengal, India, among patients aged 15 years and above. Coronal CT scan of paranasal sinus and orbit region was done. Data was collected with the help of semi structured predesigned and pretested questionnaire. Of the 44 study patients, 15.9 % had concha bullosa, 11.36 % had paradoxical middle concha, 27.3 % had Haller cell, 18.2 % had agger nasi cell. Lateral attachment and medial free margin of uncinate process

were also measured in respect to medial body line. 77.3, 59.1 and 47.7 % had sneezing, rhinorrhoea and headache respectively. The harmony of mucociliary clearance and obstruction free osteomeatal complex is the key factor for ventilation and drainage of maxillary, frontal and anterior ethmoidal air cells.

Keywords Anatomical variation · Osteomeatal complex · Medial body line · Air cells

Introduction

Osteomeatal complex represents the final common pathway for drainage and ventilation of the frontal, maxillary and anterior ethmoid air cells [1, 2]. The obstruction of this narrow region is a key factor in the development of chronic sinusitis [3–5].

Presence of pneumatization in middle turbinate, orbital floor and first ethmoturbinal constitutes concha bullosa, Haller cell and agger nasi cells respectively and regarded as **variants** among the distribution of structures of interest around osteomeatal complex [6].

The health and normal function of nose and paranasal sinuses and their lining mucus membranes depends primarily on two important factors: ventilation and drainage. Normal ventilation of the paranasal sinuses requires both a patent sinus ostium and a patent pathway (pre-chamber) connecting the ostium to the nasal cavity [3].

Description of delicate air cells around semilunar hiatus, namely Haller cells, agger nasi cells, concha bullosa, bulla ethmoidalis and uncinate process constitutes anatomical variants of osteomeatal complex and is the focus of this study.

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Liu et al. [7] have demonstrated that greater the size of anatomical variant, the higher the frequency of association with paranasal sinus mucosal alterations at CT. Different types of anatomical variants present distinct relations with either clinical or tomographic sinus disease. Main anatomical variants of osteomeatal complex are middle concha bullosa, paradoxical middle concha, Haller and agger nasi air cells, deviated nasal septum and enlarged ethmoid bulla.

By the 63rd–70th day of prenatal development, six major furrows develop in the lateral nasal wall along with their corresponding ridges or folds called the ethmoturbinals i.e., turbinates arising from the ethmoid. Stammberger divides these folds into two anatomical components, an anterior ascending portion—the ramus ascendans and a posteroinferior, more horizontal descending portion—the ramus descendans [8].

These typically fuse into fewer ridges, The descending portion of the first ethmoturbinal remains as the **uncinate process**, and the ascending portion remains as the **agger nasi** (i.e., the nasoturbinal). From these embryologic relationships, one can see that the uncinate process is actually the basal lamella of the first ethmoturbinal. Similarly, the ethmoid bulla evolves from the second basal lamella, and the middle turbinate from the **third basal lamella**.

Hence presence of anatomical variations around osteomeatal complex may adversely affect the drainage and ventilation of frontal, maxillary and anterior ethmoidal air cells causing chronic sinusitis, is the focus of present study.

Objectives

The aims and objectives of the study are

1. To determine the profile of variation of osteomeatal complex in patients attending North Bengal Medical College and Hospital, West Bengal, India.
2. To measure the dimensions (length, breadth, volume etc.) of anatomical variants when present among the study population.

Materials and Methods

It is a descriptive, hospital based study with cross sectional design done from June 2011 to May 2012 from the Department of Radiodiagnosis and Otolaryngology, North Bengal Medical College and Hospital, Sushrutnagar, Darjeeling among patients above 15 years of age for coronal CT scan of para nasal sinus and orbit region. Informed consent was obtained from patients for participating in this study. Any conditions which adversely influence anatomy of nasal cavity like cleft palate etc. were

also excluded from the current study. Sociodemographic profile, physical examination and CT scan done with Hitachi Pronto SE, Single slice, Spiral Computed Tomographic scanner with slice thickness: 2–5 mm, Table increment 3 or 4 mm in each step and gantry angulation perpendicular to orbitomeatal base line. kV peak 120 mA/s 150–200.

Following the CT scan, it was examined on screen for presence of anatomical variants. The data collected in the pretested semi structured questionnaire using the software for radiological measurements.

Operational Definition of Variants

Medial body line [9] which is the ‘reference line’ in this study, drawn radiologically extending vertically downward from the base or the lower most extent of Crista galli to the base of nasal septum. This reference line is fixed and used as basis for measuring different variants relations. The length of this reference line was measured. Variations like concha bullosa, agger nasi cell, Haller cell and paradoxical medial bent if any are measured in their dimensions with this reference medial body line.

Osteomeatal Complex

Osteomeatal complex is a functional entity of the anterior ethmoid complex that represents the final common pathway for drainage and ventilation of the frontal, maxillary, and anterior ethmoid cells [10].

Scribano et al. have defined the osteomeatal complex as a complex including the maxillary sinus ostium, ethmoid infundibulum and middle meatus; in other words, as the final site of drainage from the frontal and maxillary sinuses and anterior ethmoidal cells [11].

Haller Cells

These cells grow into the bony orbital floor that constitutes the roof of the maxillary sinus, are differentiable from the bulla, and have a potential pathophysiologic relationship to a narrowed ethmoid infundibulum or maxillary sinus ostium [11]. ‘Haller cells’ are anterior ethmoidal cells that project beyond the limits of the bulla ethmoidalis under the orbital floor, forming the infundibulum lateral wall between the papyracea lamina and the unciform process [4]. Figure 1 shows left Haller cell as marked with + sign and arrow.

Paradoxical Middle Concha

Middle concha may present a curvature convexity laterally contrary to the one normally seen; this is another anatomical variant named paradoxical middle concha and

Fig. 1 Paradoxical middle concha and Haller cell

present at CT in 30 % of patients [4, 12]. In the above Fig. 1, bilateral paradoxical middle concha is marked with PMC.

Middle Concha Bullosa

When there is pneumatization of the middle turbinate, the term concha bullosa is used. The term may also apply to pneumatization of the superior turbinate. The pneumatization of the middle turbinate usually originates from the frontal recess or the agger nasi [10]. The middle concha bullosa is a result of pneumatization of the osseous plate due to ethmoidal extension. Figure 2 shows large left concha Bullosa in coronal CT scan.

Agger Nasi Cells

The term comes from the Latin for nasal mound and refers to the most superior remnant of the first ethmoturbinal,

Fig. 2 Large left concha Bullosa in coronal CT scan

which persists as a mound or crest immediately anterior and superior to the insertion of the middle turbinate. An agger nasi cell results when this area of the lateral nasal wall under goes pneumatization. Depending on the degree of pneumatization, agger nasi cells may reach laterally to the lacrimal fossa and cause narrowing of the frontal recess [10]. The agger nasi cell is the most anterior ethmoidal cell, situated below the frontal sinus, next to the frontal recess, representing the lacrimal bone pneumatization due to ethmoidal extension.

Bulla Ethmoidalis

From the Latin, bulla ethmoidalis, where bulla means a hollow, thin-walled, bony prominence and the name refers to the largest and most nonvariant air cells in the anterior ethmoid complex. It is formed by pneumatization of the bulla lamella, or second ethmoid basal lamella, and is like a bleb on the lamina papyracea [10].

Uncinate Process

The uncinate process is a thin, bony leaflet that resembles a hook. It is oriented almost sagittally and runs from anterosuperior to posteroinferior. Its concave posterosuperior free margin is parallel to the anterior surface of the ethmoid bulla. The uncinate process attaches to the perpendicular process (lamina perpendicularis) of the palatine bone and the ethmoid process of the inferior turbinate with bony spicules. The convex anterior margin ascends to the lacrimal bone, and sometimes to the skull base or lamina papyracea, remaining in contact with the bony lateral nasal wall [10].

Results

Data was collected, collated and cleaned and were analysed using SPSS-16 for descriptive statistics and correlations. The findings are described below.

Clinically 77.3 % of study population had presenting symptom of sneezing. 59.1 % and 47.7 % of the study subjects had presenting symptoms of rhinorrhoea and headache respectively.

Among the 44 study patients, 15.9 % had concha bullosa, 11.36 % had paradoxical middle concha, 27.3 % had Haller cell, 18.2 % had agger nasi cell.

In this study population 70.5 % have deviation of nasal septum to right and 29.5 % having deviation to left.

Table 1 describes the dimensions of uncinate process where it shows that the tip or medial end of right uncinate process has a minimum distance of 4.4 mm and maximum distance of 12.4 mm with mean of 7.93 mm from MBL. It

Table 1 Distance of tip and base of uncinate process from medial body line among study population (n = 44)

Distance of uncinate process tip and base	Minimum	Maximum	Mean	SD
Right uncinate process tip (mm)	4.4	12.4	7.93	1.63
Right uncinate process base (mm)	8.0	17.7	11.89	2.11
Left uncinate process tip (mm)	2.0	11.0	7.67	1.89
Left uncinate process base (mm)	10.0	16.0	12.40	1.60

also reveals that Base or Lateral end of right uncinate process has a minimum 8 mm and maximum 17.7 mm with a mean of 11.89 mm distance from MBL.

Likewise it is documented that minimum and maximum distance of Left uncinate process tip 2 and 11 mm apart respectively from MBL with a mean of 7.67 mm and minimum and maximum distance of left uncinate process base is 10 and 16 mm apart with a mean of 12.40 mm from MBL.

Bulla ethmoidalis is described in Table 2, the mean distance of right bulla ethmoidalis from MBL is 5.45 mm with SD 2.41. The mean length, breadth and height of rt. bulla are 6.79, 6.08 and 6.61 respectively. The mean volume is found to be 141.46 mm³ with a SD of 79.07.

It also depicts that the mean distance in left bulla from MBL is 5.52 mm. The mean length, breadth and height of left bulla are 7.23, 6.32 and 6.24 mm respectively. The mean volume of Left bulla is 151.97 mm³.

It is found from the Table 3, that the mean length, breadth and height of right Haller cells are 6.1, 4.2 and 4.7 mm respectively. The mean volume was found to be 66.7 mm³. The mean distance from medial body line was 10.25 mm.

The mean length, breadth and height of left Haller cells are 5.83 and 3.56 and 4.65 mm respectively. The mean volume was found to be 49.05 mm³. The mean distance from medial body line was 11.4 mm.

The Table 4 shows the mean length, breadth, height and volume of the right agger nasi cells are 4.36, 5.16, 7.3 mm and 84.13 mm³ respectively. The mean distance of the right agger nasi cells from medial body line was 5.36 mm.

Table 2 Descriptive dimensions of Bulla ethmoidalis

Dimensions	Right bulla ethmoidalis		Left bulla ethmoidalis	
	Mean	SD	Mean	SD
Distance from MBL (mm)	5.45	2.41	5.52	1.94
Length (mm)	6.79	1.85	7.23	1.53
Breadth (mm)	6.08	2.29	6.32	1.78
Height (mm)	6.61	1.68	6.24	1.56
Volume (mm ³)	141.46	79.07	151.97	79.77

The mean length, breadth, height and volume of the left agger nasi cells are 5.25, 4.85, 5.55 and 68.4 mm³ respectively. The mean distance of the left agger nasi cells from medial body line 4.30 mm.

The above Table 5, shows that mean distance of right concha bullosa from medial body line is 1.36 mm. The mean length, breadth and height of right concha bullosa are 8.4, 8.2 and 10.44 mm respectively. Mean volume of right concha bullosa is 381.9 mm³.

Table 3 Descriptive dimensions of Haller cell

Dimensions	Right Haller cells		Left Haller cells	
	Mean	SD	Mean	SD
Distance from MBL (mm)	10.25	1.79	11.40	2.42
Length (mm)	6.10	2.50	5.83	1.55
Breadth (mm)	4.20	2.14	3.56	0.37
Height (mm)	4.70	1.08	4.65	1.78
Volume (mm ³)	66.72	61.79	49.05	25.52

Table 4 Descriptive dimensions of agger nasi cell

Dimensions	Right agger nasi cell		Left agger nasi cell	
	Mean	SD	Mean	SD
Distance from MBL (mm)	5.36	1.73	4.30	0.69
Length (mm)	4.36	0.49	5.25	0.86
Breadth (mm)	5.16	0.69	4.85	0.17
Height (mm)	7.30	0.70	5.55	1.32
Volume (mm ³)	84.13	24.34	68.4	2.77

Table 5 Descriptive dimensions of concha bullosa

Dimensions	Right concha bullosa		Left concha bullosa	
	Mean	SD	Mean	SD
Distance from MBL (mm)	1.36	0.35	2.4	0.10
Length (mm)	8.48	1.22	10.30	3.76
Breadth (mm)	8.28	4.86	5.86	1.50
Height (mm)	10.44	0.60	10.16	1.42
Volume (mm ³)	381.92	259.71	307.04	139.09

The mean length, breadth and height are 10.30, 5.86 and 10.16 mm respectively. The mean volume of the left concha bullosa was found to be 307.04 mm and the distance from medial body line varied was 2.4 mm.

Discussion

The genesis of rhinosinusitis is multifactorial, and the physiological factor (mucociliary clearance) possibly is as much important as the mechanical obstructive factor [13]. Indications for surgical correction of the sinus drainage deal with the possibility of presence of an anatomical variant as an obstructive factor.

Presence of this obstructive factor principally at the level of osteomeatal complex requires precise location but there is limited reference to objective parameters like dimensions of anatomic variant or drainage pathways amplitude as specific indicators [14, 15].

Clinical profile are mentioned in the present study in three (3) parameters namely presence of sneezing, rhinorrhoea and headache. The present study shows that 77.3 % of population had presenting symptom of sneezing, whereas 59.1 and 47.7 % of study population had presenting symptoms of rhinorrhoea and headache.

Tonai and Baba showed that 76 % of study population in their study was symptomatic (having chronic sinusitis). But Bolger et al. stated that 82 % of the study subjects were symptomatic, 18 % were asymptomatic or those who were non sinus symptoms.

Concha bullosa (pneumatised middle turbinate) has been implicated as a possible aetiological factor in the causation of recurrent chronic sinusitis. It is due to its negative influence on paranasal sinus ventilation and mucociliary clearance in the middle meatus region. The present study reveals that 4.5 % of the population had concha bullosa in the right side and 4.5 % of the study population had concha bullosa in the left side. Concha bullosa was present in both sides in 6.8 % population.

The total number of concha bullosa in the study population was 15.9 %. This is similar with the findings of Mamatha et al. [16] and Lloyd [17] who found 15 and 14 % of their study population having concha bullosa.

In the present study 11.36 % of the study population shows paradoxical medial bent of middle turbinate or paradoxical middle concha. Wani et al. [18] shows 9.33 % of the study population in his study has paradoxical middle concha. Similarly 12 and 12.87 % of study population have paradoxical middle concha in their study by Azila et al. [19] and Bolger et al. [12].

The present study reveals that deviation of nasal septum to right is 70.5 % and deviation to left is 29.5 %. Mamatha et al. [16] found 25 % population and Wani et al. [18]

found 25.33 % population has DNS to left which is in accordance to the present study.

Presence of agger nasi air cells may compress the infundibulum and adversely affect the drainage and ventilation of frontal air cells. In the present study, 9.1 % agger nasi air cells are found in right side and 4.5 % found in left side. Agger nasi cells are present in both sides of 4.5 % of the study population whereas total 18.2 % of the study population showed agger nasi air cells. This is similar with the study by Riello and Boasquevisque [20] and Wani et al. [18] whose findings were 13.5 and 9.33 % respectively.

In the present study 6.8 % Haller cells are present in right side and 9.1 % cells are present in left side. 11.4 % of the population has cells in both sides with a total no of cells present in 27.3 % of the study population. This result is similar with the study conducted by Riello and Boasquevisque, Zeinrich et al. who found 10 % Haller cell in their study [20, 21]. Raina et al. noted 16 % of the study population possesses Haller cell [22]. Mamatha et al. documented 17.5 % Haller cell in their study [16].

Medial body line which is a reference line in this study alone holds strong predictive power for different anatomical variants. It is imperative that requests from consultants and residents of ENT surgery for furnishing few radiological measurements will enrich their health care delivery pattern. It is this concerted effort of clinical and imaging support for the description of osteomeatal complex, which is the functional unit of the anterior ethmoid complex representing the final common pathway for drainage and ventilation of the frontal, maxillary and anterior ethmoid sinuses.

Summary and Conclusion

The harmony of mucociliary clearance and obstruction free osteomeatal complex is the key factor for ventilation and drainage of maxillary, frontal and anterior ethmoidal air cells. Presumably, these variations might induce osteal obstruction, preventing mucus drainage and predisposing to chronic rhinosinusitis. Concha bullosa is a common anatomic variant.

Recommendation

Paranasal sinus pathophysiology causing chronic rhinosinusitis is presumably dependent largely on the anatomy of osteomeatal complex and its variants when present.

The single most important investigation for the assessment of osteomeatal complex is coronal CT scan. Assessment of anatomical variation in coronal CT scan with measurement of few basic parameters along with

description of anatomical variants seems invaluable for the management planning including medical and surgical intervention for chronic rhinosinusitis. This will also help the otorhinolaryngologist or radiologist to evaluate the CT of paranasal sinuses better. This will, in turn, help in endoscopic examination as well as in FESS.

Compliance with Ethical Standards

Funding The study was conducted without any funding or sponsorship.

Ethical Standards No animal experiment was done during this study.

Conflict of Interest The authors declare that they have no conflict of interest.

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